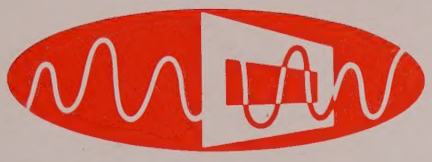


INSTRUCTION MANUAL

FOR

POWER METER

NARDA MODEL 440

narda

the narda microwave corporation
MINEOLA, NEW YORK.

INSTRUCTION MANUAL

F O R

POWER METER

NARDA MODEL 440

INSTRUCTION MANUAL FOR POWER METER

NARDA MODEL 440

FUNCTIONAL DESCRIPTION

The microwave power meter may be used to give accurate direct readings of CW or pulsed power automatically. This instrument may be used in any frequency range for which mounts are available. The power meter may be used with all elements, either positive or negative temperature coefficients operating at 100Ω or 200Ω levels and requiring bias currents up to 18 ma. Seven ranges of power levels may be measured permitting direct power readings from 0.001 to 10.0 mw or in dbm from -30 to +10. Higher power levels up to 4.0 watts may be measured by means of appropriate attenuators.

SPECIFICATIONS

POWER RANGE

7 ranges - full scale readings
0.01, 0.03, 0.1, 0.3, 1.0, 3.0, 10.0 mw
-30 to -20 db, -25 to -15 db, -20 to -10 db, -15 to -5 db,
-10 to 0 db, -5 to +5 db, 0 to +10 db.

(Reference is 1 mw across either 100Ω or 200Ω depending upon element used.)

Attenuators and/or directional couplers can be used to extend power range upward.

Lower two ranges to be used under stable thermal conditions.

EXTERNAL SENSING ELEMENTS

Frequency ranges are determined by mounts. Provision is made for supplying a continuously variable dc bias current up to 18 ma. to the element. Either 100Ω or 200Ω operating resistance of the element for both bolometer and thermistor.

ACCURACY

±3% of full scale reading.

POWER

Nickel cadmium battery (rechargeable).
Built-in battery charges operating from 115 v,60 cycle line. Unit will operate for 16 hours starting with battery fully charged before recharge is required.

IMPORTANT

Recharge battery overnight (15 hours). Power meter can be operated while battery is being charged without detriment to performance. Recharge cycle will be prolonged however. Battery may be charged for up to 90 days continuously (with power meter not in use) without damage to battery.

CONTROLS & CONNECTIONS

SELECTOR - 100Ω positive, - 200Ω positive - OFF - 200Ω negative - 100Ω negative.

CHARGER - Off-On.

RANGE SWITCH - .01 to 10 mw.

ZERO - Coarse and Fine.

BIAS - Off-0 to 18 ma.

INPUT - BNC.

POWER REQUIREMENTS

External power required to recharge the self-contained battery. Power requirements for this function are 115 volts, 60 cycles 2.1 watts.

FUNCTIONAL OPERATION

The NARDA MODEL 440 consists of a self-balancing audio bridge. The self-balancing circuit acts to maintain the specified operating resistance of the external thermal sensitive element which is inserted in one branch of the bridge. Since the feedback to the bridge is audio power, any increase of rf or dc power into the element will be accompanied by an equivalent decrease in audio level. By the substitution method it is the change in audio power which is measured to determine the rf power. To make a power measurement the dc bias current is first adjusted to zero the meter. This places the audio power at a known level. With the application of rf power an equivalent amount of audio power is automatically removed which results in an upscale meter deflection which directly indicates the rf power.

DESCRIPTION OF CONTROLS

SELECTOR SWITCH

This is a five position rotary switch permitting the operator to select the type of element to be used in conjunction with the power meter to be either 100Ω positive or negative temperature coefficient or 200Ω positive or negative. The center off position turns off the power meter with the exception of the built-in charger.

CHARGER SWITCH

This two position lever switch turns the power to the battery charging circuits on and off. This switch operates completely independently of the rest of the power meter permitting operation of the battery charger either while the instrument is in use or during periods when it is not being operated.

RANGE SWITCH

This switch is a seven position rotary switch permitting the operator to select the appropriate meter scale to read a specified power range.

ZERO SET

This dual concentric potentiometer permits coarse and fine adjustment of the element bias for purposes of zeroing the meter.

BIAS RANGE POTENTIOMETER AND SWITCH

This potentiometer with switch at the extreme counter clockwise position permits the operator to turn the bias current on and adjust it to the approximate value required for zeroing the meter. It should be noted that this bias control is overridden by the selector switch position which determines whether the entire unit (with the exception of the charger) is on or off.

SEQUENCE OF OPERATION

(1) Select an appropriate mount, either waveguide or coaxial.

(2) Place power meter in operation by setting the selector switch to the appropriate ohmic value and temperature coefficient. Set the range switch to 10 mw and adjust the zero set controls to approximately the center of their range. Set the bias range potentiometer and switch to OFF.

(3) Connect the audio cable from the mount to the input connector on the power meter.

(4) Adjust the bias range potentiometer to approximately zero the meter. Carefully adjust the coarse and fine zero set controls to exactly zero the meter. Apply the RF power and note whether an indication is obtained on the meter.

(5) If a very small indication is obtained, or if no indication is obtained, repeat the procedure in 2, 3 and 4 successively setting the range switch one step downward at a time and checking for an indication on the meter.

(6) After use the bias range potentiometer and switch should be set to OFF. The selector switch should also be set to the center OFF position.

(7) The battery charger must be turned on at intervals in order that the unit may be ready for operation whenever required. Connect the line cord to the 115 volt 60 cycle power line. Turn the charger switch to ON.

NOTE 1

The power meter will operate for approximately 16 hours starting with a fully charged battery before recharge is required. The time required to recharge a fully discharged battery is approximately 16 hours. The battery will withstand continuous charging for a period not to exceed 90 days. When the battery is being charged while the power meter is in operation the charging rate is reduced to approximately one-quarter the normal charging rate.

NOTE 2

In using the lower ranges of the power meter care must be exercised in obtaining and maintaining stable thermal operating conditions for the sensing element. In addition, the lower current elements are recommended for use on these lower ranges (.01 to .1 mw). These elements are 200Ω low power high sensitivity units and are available in the crystal and disc configurations. Extra caution must be observed in the use of these elements because of their lower burnout power level, but with their judicious utilization lower scales of the power meter become more useful in a practical sense because of the drift reduction that is effected. Such units are the Narda N610B-4.5, PRD610A Bolometer in the crystal configuration, and the Narda N603-4.5 and PRD631C Bolometers in the disc configurations.

NOTE 3

The surfaces of this plastic meter case have been treated with a special preparation in order to minimize the electrostatic properties which are characteristic of such plastics. Dust should be removed by blowing, NOT RUBBING. Hard rubbing or cleaning with a damp cloth will destroy the anti-static treatment. In order to restore anti-static effect, it is recommended that the top meter case be wiped lightly with a piece of absorbent cotton which has been saturated with a mild solution of liquid household detergent such as JOY. Allow the meter case to dry before handling.

PRINCIPLES OF OPERATION

The components of a self-balanced bridge are essentially those shown in Figure 4-1. The circuit consists of a Wheatstone bridge, a high-gain audio amplifier with a voltmeter across the output, a feedback circuit to provide for oscillation, and a dc bias network. The thermal sensitive element which is placed in one arm of the bridge, has an initial resistance which is different from the operating resistance of the bridge. The large feedback factor of the circuit permits large amplitude oscillations which rapidly changes the resistance of the thermal sensitive element. Equilibrium occurs when the element resistance is slightly different than the operating resistance of the bridge.

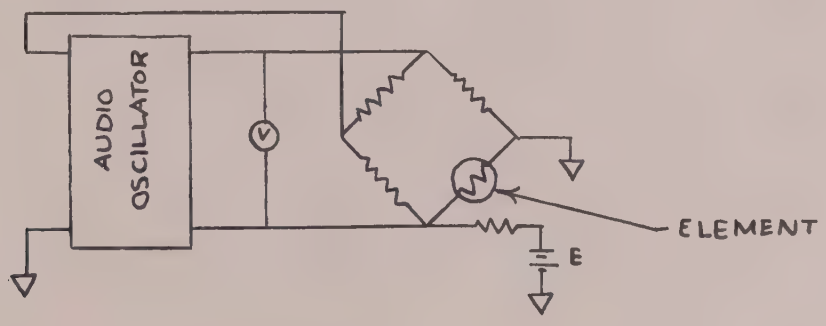


Figure 4-1

The oscillation frequency of the bridge is 9850 cycles. Since the bridge circuit tends to maintain the element's resistance at its specified operating value, an increase of RF or DC power into the element would cause an equivalent decrease of audio power. This decrease in audio power is used to determine the RF power. The voltmeter circuit across the output of the oscillator measures the average bridge voltage. A DC current is supplied to the meter in the forward direction, and rectified audio is applied in the reverse direction. Therefore, for a decrease in audio signal, an upscale deflection occurs. The voltmeter scale is calibrated in power units. For any range of measurements the DC bias current is adjusted so that the rectified audio current bucks out the forward DC current in the meter. The audio power, which is then at a known level, decreases as the element is exposed to the RF energy. The meter deflects upscale thereby giving the RF power reading directly. Typically, on the 10 mw range when the meter is adjusted to zero the audio power in the element is 12.0 mw. When the meter indicates full scale this audio power reduces to 2.0 mw, the differential of 10.0 mw being the power measured by that scale.

CALIBRATION

Connect a vacuum tube voltmeter of high input impedance which measures AC voltages to the calibrate jack in the rear of the unit. With the power meter in operation on the 1 mw scale, with either a 200Ω bolometer or thermistor element, adjust the bias controls so that the VTVM indicates 0.200 volts. Set the full scale adjust potentiometer R56 so that the power meter indicates full scale. Readjust the bias controls so that the VTVM reads 0.490 volts. Adjust the zero adjust potentiometer R49 so that the power meter reads zero. Recheck these readings several times to insure that any interaction between the two adjustments has not affected the settings. The metering circuit has now been calibrated.

To calibrate the bridge circuit place a decade resistance box across the input terminals and check the resistance at which the bridge operates for each of the four possible operating conditions, positive coefficient 100Ω and 200Ω and negative coefficient 100Ω and 200Ω. This operating resistance can be determined within a half percent by observing the resistance at which the bridge oscillates and then stops oscillating as the resistance of the decade box is changed in steps of 1Ω or less. Oscillation will be indicated by an off-scale down-scale reading of the power meter, and non-oscillation will be indicated by an off-scale up-scale reading. Adjustment of the operating resistance can be made for the four operating positions independently by means of potentiometers R12, R13, R14 and R 15.

INSTRUCTION MANUAL MODEL 440

APPENDIX

On NARDA Model 440 Power Meters serial numbers 200 and up the function of the charger switching has been changed as follows:

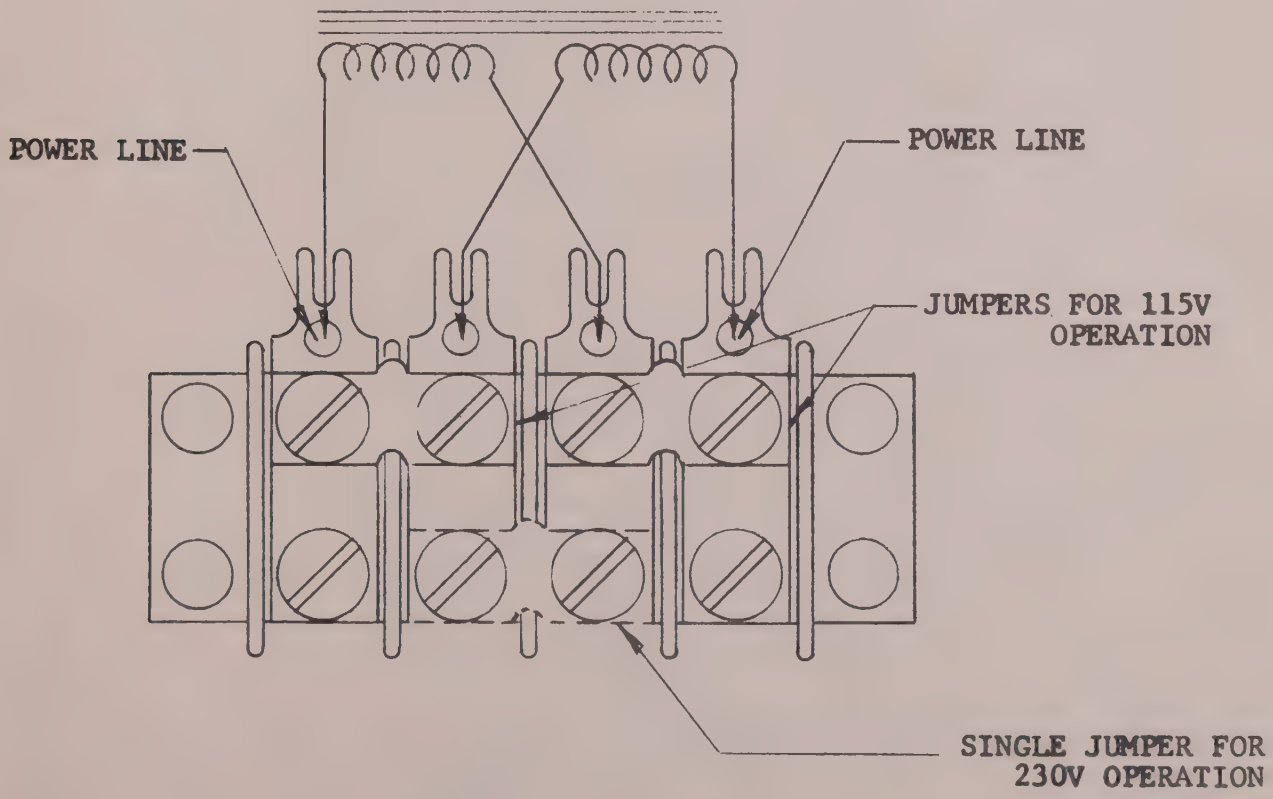
> When the line cord is plugged into a 115V power line the battery is charging regardless of the position of all other function switches. The panel lamp marked CHARGING will be illuminated to indicate this. The horizontally oriented lever switch has a momentary position to the left. When this switch is held in this momentary CHECK position the battery voltage is indicated by the main panel meter. The red line on the top scale of the meter marked BATTERY MINIMUM corresponds to a battery voltage of 11.5 volts. For proper operation of the power meter this CHECK should cause a meter indication equal to, or higher than, the BATTERY MINIMUM line. With the lever switch in the momentary CHECK position the charger is switched off as indicated by extinguishing of the CHARGING indicator, and power measurements cannot be made inasmuch as the panel meter is switched out of the power metering circuit. Portable operation of the power meter is possible by simply disconnecting the line cord from the power line. During portable operation battery voltage checks may be made periodically by means of the momentary switch to determine when the battery needs recharging.

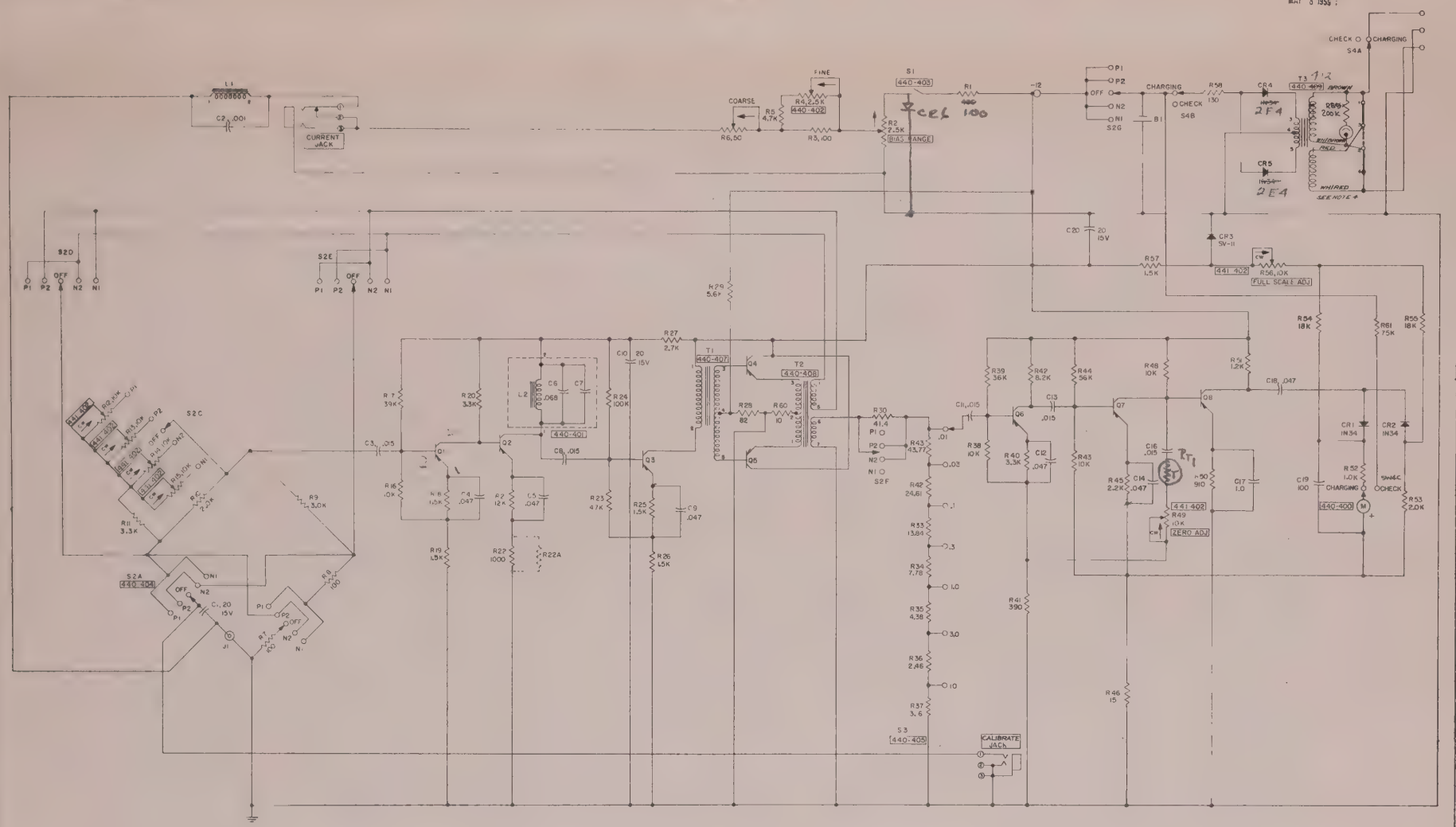
INSTRUCTION MANUAL FOR POWER METER

NARDA MODEL 440

APPENDIX B

For Serial Nos. 200 and up, provision has been made for either 115 volt or 230 volt operation of the internal battery charger. Shown below is a sketch of the barrier terminal strip accessible from the underside of the chassis. The dual wound primary windings of the transformer are shown schematically as they are connected to the terminal strip. As shipped from the factory the jumpers are placed to permit operation from a nominal 115 volt power line. The dual primary transformer windings are in parallel (properly phased) for this operation. For operation from a nominal 230 volt power source remove both jumpers and insert one only across the two centre terminals per the dotted jumper shown in the sketch. The transformer primary windings will be placed in series (properly phased) for nominal 230 volt operation with the single jumper across the centre terminals.





NOTES:
1. ALL RESISTORS IN OHMS
2. ALL CAPACITORS IN MICROFARADS
3. THIS DWG. APPLICABLE FOR UNITS #225 AND UP.
4. (a) FOR 115 V OPERATION ADD JUMPERS AS ABOVE FROM 1 TO 3 & 2 TO 4
(b) FOR 230V OPERATION REMOVE JUMPER FROM 1 & 3 & 2 & 4 & CONNECT JUMPER PER DOTTED CONNECTION BETWEEN 2 & 3

			SCHEMATIC, POWER BRIDGE	narda
				E 440-504 C

ACCURACY OF NARDA MODEL 440 POWER METER

Inasmuch as a direct R-F method for checking power meter accuracy within the specified ± 3% limits is tedious and requires rather elaborate equipment, some other method should be considered which requires only low frequency measurements of voltage and resistance.

Basically the power meter consists of a voltmeter and a self-balancing bridge. The self-balancing bridge maintains the operating resistance of the sensing element at a given value (100 ohms or 200 ohms). Over the entire operating range of the power meter the change in this operating resistance is negligible. The voltmeter measures the audio voltage across the bridge circuit (and hence the signal required to balance the bridge which, by power substitution, is inversely proportional to power applied to the sensing element.)

Power applied to the sensing element may be expressed as: $P = E^2/R$. Accuracy of E^2 and R terms will determine the overall measuring accuracy. The standard calibration procedure for NARDA Model 440 Power Meter permits adjustment of the element resistance to within 0.1% using a decade resistance box of 0.01% accuracy. The maximum total error for R is therefore 0.11%.

Two additional adjustments of the voltmeter circuit gain provide adjustment of the E term to within the accuracy of the calibrating voltmeter which must be better than 0.1%. (Calibrating meter accuracy must be this good only at 2 discrete points on the scale). The NARDA Power Meter has a meter movement linearity of 1%. Selected resistors in the voltage divider network for range switching are held to 0.2%. Voltage measurement is made of the total voltage applied across the bridge, and therefore the accuracy of the 100 ohms or 200 ohms resistor (refer to schematic diagram) in the fixed arm of the bridge directly affects the voltage measurement. These two fixed resistors are held within 0.1%. Since the E term appears to the second power in the power equation a 1.4% voltage error (0.1% + 1% + 0.1% + 0.2%) will result in 2.81% power error. Upon the addition of the 0.11% error possible for R the overall accuracy will be at worst 2.92%.

The only remaining sources of error not checked in the instrument are the self-balancing oscillator and the voltmeter circuit linearities. Careful measurements of signal input vs. signal output of these circuits show no detectable deviation from linearity over the entire operating range.

A final consideration should be that of temperature variation. All of the circuits in the power meter have been temperature compensated. Even so, the ultimate in accuracy will be achieved if the calibration procedure is carried out at the temperature at which the unit is expected to be operated. Large temperature variations will affect the calibration and therefore the overall accuracy of the unit.

TABLE OF REPLACEABLE PARTS

FOR

NARDA MODEL 440

DESIGNATION	PART NO.	DESCRIPTION	MANUFACTURER
B1	10V0.500	Battery 12V 500 MAH	GULTON INDUSTRIES
C1, C10, C20	30D167	Capacitor, 20µf, 15V	SPRAGUE
C2	109P10292	" .001µf 200vdc	SPRAGUE
C3, C8, C11, C13, C16	109P15302	" .015µf 200vdc	SPRAGUE
C4, C5, C9, C12, C14, C18	109P47302	" .047µf 200 vdc	SPRAGUE
C17	30D121	" 1µf, 6V	SPRAGUE
C19	30D135	" 100µf, 6~~00~~ V	SPRAGUE
CR1, CR2 CR4, CR5	1N34 2E4	Diode DIODE	-- INT'L. RECT.
CR3	SV-11	Voltage Reference Diode	TRANSITRON
I1	NE-51	Lamp	NEON BULB
J1	UG/1094/U	BNC Receptacle	--
J2	13B	Jack	SWITCHCRAFT
J3	12B	Jack	SWITCHCRAFT
L1	440-406	Choke	NARDA
I2, C6, C7	440-401	Tuned Circuit Assy.	NARDA
M1	440-400	Meter	NARDA
Q1 thru Q8	2N270	Transistor	R. C. A.
R1	EB-1/2	Resistor, ~~430Ω~~ 100 Ω ±5%	ALLEN BRADLEY

DESIGNATION	PART NO.	DESCRIPTION	MANUFACTURER
R2, S1	440-403	Switch, Potentiometer	NARDA
R3	EB-1/2	Resistor, 100Ω ±5%	ALLEN BRADLEY
R4, R6	440-402	Dual Potentiometer	NARDA
R5	EB-1/2	Resistor, 4.7K ±5%	ALLEN BRADLEY
R7, R8	440-R7 440-R8	" 100Ω±0.1%	NARDA
R9	440-R9	" 3.0K,±0.5%	NARDA
R10, R53	EB-1/2	" 2.0K,±5%	ALLEN BRADLEY
R11, R20, R40	EB-1/2	" 3.3K,±5%	ALLEN BRADLEY
R12, R13, R14 R15, R49, R56	441-402	Potentiometer	NARDA
R16, R38, R43 R48	EB-1/2	Resistor, 10K,±5%	ALLEN BRADLEY
R17	EB-1/2	" 39K, ±5%	"
R18, R19, R25 R26, R57	EB-1/2	" 1.5K, ±5%	"
R21	EB-1/2	" 12K, ±5%	"
R22, R52	EB-1/2	" 1.0K, ±5%	"
R23	EB-1/2	" 47K, ±5%	"
R24	EB-1/2	" 100K, ±5%	"
R27	EB-1/2	" 2.7K, ±5%	"
R28	EB-1/2	" 82Ω, ±5%	"
R29	EB-1/2	" 5.6K, ±5%	"

DESIGNATION	PART NO.	DESCRIPTION	MANUFACTURER
R30	440-R30	Resistor 41.4Ω ±0.2%	NARDA
R39	440-R31	" 43.77Ω ±0.2%	NARDA
R32	440-R32	" 24.61Ω ±0.2%	NARDA
R33	440-R33	" 13.84Ω ±0.2%	NARDA
R34	440-R34	" 7.78Ω ±0.2%	NARDA
R35	440-R35	" 4.38Ω ±0.2%	NARDA
R36	440-R36	" 2.46Ω ±0.2%	NARDA
R37	440-R37	" 3.16Ω ±0.2%	NARDA
R39	EB-1/2	" 36K, ±5%	ALLEN BRADLEY
R41	EB-1/2	" 390Ω ±5%	ALLEN BRADLEY
R42	EB-1/2	" 8.2K ±5%	ALLEN BRADLEY
R44	EB-1/2	" 56K ±5%	ALLEN BRADLEY
R45	EB-1/2	" 2.2K ±5%	ALLEN BRADLEY
R46	EB-1/2	" 15Ω ±5%	ALLEN BRADLEY
R50	EB-1/2	" 910Ω ±5%	ALLEN BRADLEY
R51	EB-1/2	" 1.2K ±5%	ALLEN BRADLEY
R54, R55	EB-1/2	" 18K ±5%	ALLEN BRADLEY
R58	EB-1/2	" 130Ω ±5%	ALLEN BRADLEY
R59	EB-1/2	" 200K ±5%	ALLEN BRADLEY
R60	EB-1/2	" 10Ω ±5%	ALLEN BRADLEY
R61	Type MDC	" 75K ±1%	IRC

MODEL 440 (continued)

DESIGNATION	PART NO.	DESCRIPTION	MANUFACTURER
S2	440-404	Selector Switch	NARDA
S3	440-405	Range Switch	NARDA
S4	1457	Charge Switch	CENTRALAB
T1	440-407	Transformer	NARDA
T2	440-408	"	NARDA
T3	440-~~409~~ 412	"	NARDA
CR6	ME210T10	ZENER DIODE	INT'L. RECT.
RT1	28D13	THERMISTOR	VICTORY ENG'RG.